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Author's address: Prof. Dr. Hellmut Grabert, Geologisches Landesamt Nordrhein-Westfalen, Postfach 1080, D-4150 Krefeld

The adrenal gland weights of the African elephant, *Loxodonta africana*

By J. Baranga

Zoology Department, Makerere University, Kampala, Uganda

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Abstract

Adrenal glands were collected from 71 male and 172 female elephants shot in Western Uganda in the period 1973 to 1974. This took place in Murchison Falls and Queen Elizabeth National Parks and included both the dry and wet seasons. The analysis of the material collected, revealed a variety of facts. The right adrenal gland is consistently heavier than the left one. There is very little sex difference in adrenal weights of coeval specimens. Adrenal weights generally increase pari passu with age in the young animals. The female elephants exhibit adrenal weight changes with the reproductive states but this is not significant. There is no evidence of seasonal or geographical variation in the adrenal gland weights of elephants of the same age and/or sex. Suggestions are put forward to try and account for the observations made.

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Introduction

The mammalian adrenal gland is structurally and functionally made of two distinct parts namely the medulla surrounded by the cortex. The size of the adrenal cortex, estimated by adrenal weight has been used as an indirect measure of function in mammals. Preliminary to use of the adrenal size in this kind of functional assessment, an understanding of seasonal changes in adrenal weights relative to body weight is necessary. Changes occur in relation to nutrition, reproductive states and population densities; sexual and species differences of variable magnitudes are also known. But adrenal changes in the biggest terrestial mammal are not well known (Krumrey and Buss 1969).

African elephants are not normally subject to the extreme temperature variations encountered by mammals living in temperate regions. In addition, it is reported that in Western Uganda the elephants breed throughout the year with no distinct seasonal acceleration (Buss and Smith 1966). Much of the work on the adrenal glands has been done on small temperate mammals (Baranga 1980). Although considerable research has been conducted on the African elephants, information on its adrenal gland is still limited (Hill et al. 1953; Krumrey and Buss 1969; O'Donoghue et al. 1967).

An opportunity for the material presented itself during the elephant population appraisal exercise in Western Uganda (Malpas 1977). Unlike previous studies on the adrenal glands of *Loxodonta africana,* this study had access to a larger sample size and thus should provide reliable information on the adrenal weights in this species. This paper presents findings on the adrenal gland weight changes in relation to sex, age, reproductive states and the adrenal gland symetry or lack of it.

Materials and methods

The work reported here is based on adrenal glands of 71 male and 172 female elephants shot in western Uganda (Malpas 1977). The animals were collected on both sides of Kazinga channel in the Queen Elizabeth National Park and on both sides of the Nile in Murchison Falls National Park. This exercise extended over both the dry and wet seasons of 1973 and 1974.

The habitat

Queen Elizabeth National Park (1,979 sq–km) is situated just to the South of the Rwenzori mountains in the western branch of the East African Rift Valley. It straddles the equator and includes Kazinga channel, which joins Lakes Edward and George. The altitude ranges between 910 and 1350 meters but most of it lies below 1100 meters above sea-level. The rainfall varies from 600 to 1400 millimeters per annum; and falls mainly during March to May and September to November.

Murchison Falls National Park is larger than, and almost twice as big as, Queen Elizabeth National Park. It is situated in Northwestern Uganda. It is bisected by the Victoria Nile joining Lakes Kyoga and Albert. It lies between 600 and 1000 meters above sea-level. Its rainfall is characterised by a short dry season between December and February, which is followed by a long wet season from March to November with peaks in April/May and September/October.

Daylength in Uganda is about 12 hours all the year round. The annual and daily temperature fluctuations are not much; and the range between the lowest and the highest temperature is not more than 10 °C. Thus, extreme temperature variations are not a factor here. Vegetation is mainly a mixture of forest and savannah woodland in Queen Elizabeth National Park; and grassland in Murchison Falls National Park (Langdale-Brown et al. 1964).

The elephants

The sex of each elephant shot was noted and each specimen assigned a code number by which the salvaged tissues were also identified. The specimens were divided into immature and mature males and females by the method of Laws and Parker (1968). The age classes were based on the estimated age

(Malpas 1977) and include immature (pre-puberty), puberty, nonbreeding and breeding. Pregnant elephants were categorised into early pregnancy, midpregnancy and late pregnancy according to the estimated age of their fetuses. Lactating females were nonpregnant mothers in which it was possible to express milk.

The glands

The adrenal glands were removed as quickly as possible after the death of the animals. Work started in the field where the glands were quickly cleaned of the surrounding adipose tissue. The clean glands were individually weighed (to the nearest 0.1 g) and then hooked with an identification tag before fixing in 10 % neutral formalin for further processing. Length and width measurements (to the nearest 0.1 cm) were made on the fixed tissues in the laboratory. Absolute adrenal weight is the total weight of the paired gland. Relative adrenal weight refers to absolute adrenal weight of the gland (g) divided by the weight (kg) of the animal.

Results

Right and left adrenals

Despite the individual variations, the majority of elephants (80 %) have havier right than left adrenals, and certainly this is always true of the mean figures calculated for all age groups in both sexes. The difference, between the two adrenal weights was found to be negligeable in fetuses; and it increased with the age of the animals, until the largest mean differences of 17.1 g was recorded in the oldes breeding females. Comparisons of the left and right adrenal glands in reference to the age classes revealed that the greatest difference is found in the oldest specimens whether or not they are actively breeding (Tab. 1).

Table 1

Adrenal gland weights of some elephants

Males						Females					
Age (Years)	Body Weight (kg)	Right	Left	PA	RA	Age (Years)	Body Weight (kg)	Right	Left	PA	RA
0–½	105	7.7	6.5	14.2	0.135	1	228	10.5	10.8	21.3	0.0934
1	248	9.0	9.0	18.0	0.073	3	737	28.0	26.0	54.0	0.0733
2	476	22.0	18.0	40.0	0.084	4	758	28.2	26.0	54.2	0.0750
3	551	18.0	16.0	34.0	0.062	6	1011	36.5	32.0	68.5	0.0678
4	625	26.0	26.0	52.0	0.083	8	1562	44.4	39.4	83.8	0.0537
6	1116	33.5	34.2	67.7	0.061	10	1427	45.5	52.0	97.5	0.0683
8	1475	47.0	42.0	89.0	0.060	13	1953	60.0	61.0	121.0	0.0620
10	1708	52.0	49.0	101.0	0.059	15	2788	79.0	64.0	143.0	0.0858
13	2533	68.0	60.0	128.0	0.051	17	2959	82.0	63.0	145.0	0.0490
15	2438	80.0	65.0	145.0	0.059	18	2763	70.0	76.0	146.0	0.0528
20	2785	81.0	73.0	154.0	0.055	20	2378	81.0	70.0	151.0	0.0635
22	3452	90.0	79.0	169.0	0.049	22	2642	80.0	84.1	164.0	0.0621
24	3406	106.0	90.0	196.0	0.058	24	2354	96.0	80.0	176.0	0.0748
26	3190	120.0	103.0	223.0	0.070	25	2837	106.0	74.0	180.0	0.0635
28	4089	132.0	114.0	246.0	0.060	26	3480	98.0	89.0	187.0	0.0537
30	3252	98.0	80.0	178.0	0.055	28	2885	94.0	92.0	186.0	0.0645
						30	3480	114.0	102.0	216.0	0.0621
						32	3330	120.0	124.0	244.0	0.0733
						34	1976	121.0	101.0	222.0	0.1124
						36	2959	124.0	116.0	240.0	0.0811
						39	3505	131.0	112.0	243.0	0.0693
						43	4037	154.0	124.0	278.0	0.0688
						45	2984	147.0	152.0	299.0	0.1002
						47	3493	153.0	141.0	294.0	0.0842
						49	2959	162.0	140.0	302.0	0.1021
PA = Absolute adrenal weights (g)						53	3355	178.0	162.0	340.0	0.1013
RA = Relative adrenal weights (g/kg)						60	3757	187.0	210.0	397.0	0.1057

Sex differences

Absolute and relative adrenal gland weights are compared for both male and female elephants of the same age. It would appear that in most cases female elephants have heavier adrenal glands than males of the same age. The small differences observed in such a comparison (Fig. 2) however, are not only insignificant but most importantly inconsistent, at least, for the age groups studied. I should add that adrenal weights for most age groups of both sexes up to 30 years are much closer than they vary.

Male elephants have lower relative adrenal weights than their coevals at 11 to 25 years of age. This is a period of initial sexual activity; and it is also likely that the body weight is increasing at a rate faster than the adrenal weights. As mature male elephants are heavier than females of the same age, and absolute adrenal gland weights tend to differ little between the sexes it is pertinent that this would result in low relative figures. There is no apparent increase in adrenal weights attributed to sexual maturity.

Age related changes

Absolute adrenal weights increase with age as they do with body weights in both sexes, and this relationship is generally linear (Fig. 1). On the other hand, the curve of the relative adrenal weights starts high in the very young elephants. It drops with increase in age until it hits the base at about 20 to 25 years of age from where it raises and does not fall again. It follows a similar trend as the absolute adrenal weight in adult elephants. The raise of the relative adrenal weight curve from about 20 years of age is less steep than the fall of the same curve experienced in the first six years of age. The low relative figures coincide with the initial sexual activity and early breeding in the life of young adults (Fig. 2). It should be noted here that the sample in the last three age groups was small.

The lowest absolute adrenal gland weight (for a pair of adrenals) recorded, was 14.2 g obtained from a male specimen only a few weeks old. The highest figure of 397.0 g was recorded from an old female specimen. The rest of the absolute adrenal weights are found

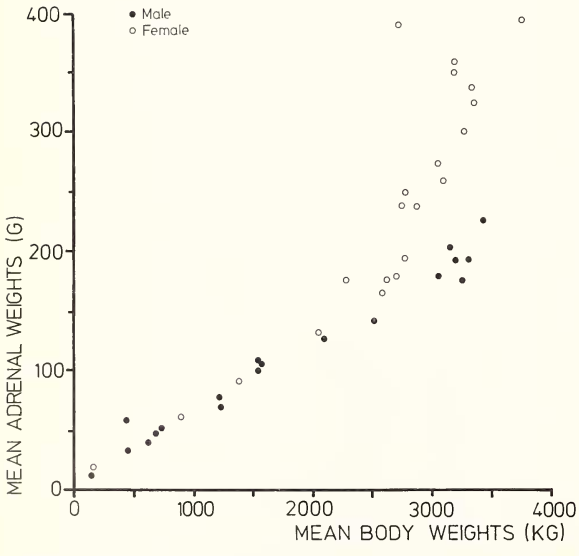

Fig. 1. Relationship between adrenal and body weights of the African elephant

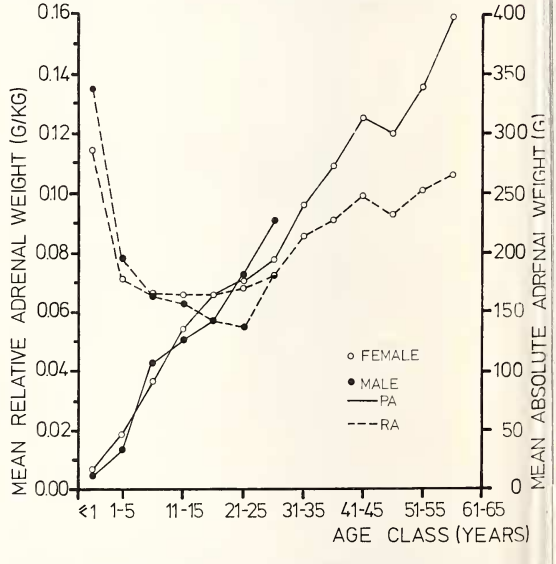

Fig. 2. Adrenal weight variation with age of the African elephant. PA = Absolute adrenal weight; RA = Relative adrenal weight

between these two extremes. The mean absolute adrenal weights at sexual maturity are 136 g for females and 128 g for males. Both female and male juvenile elephants do not attain the adult adrenal weight until they are breeding. Even when individual figures are considered, there is no adult absolute adrenal weight in the large juvenile adrenal weight range.

The bigger-tusked male elephants are preferred, by the poachers, to the smaller-tusked females and this gives the latter a chance to live longer than the former. Therefore, most of the elephants 30 years of age and more in this study were females. Thus the highest mean absolute adrenal weight of 252.0 g was recorded in the oldest females.

Changes associated with breeding

At estimated pubertal stage the female mean absolute adrenal weights are 123.5 g compared to 60.9 g at pre-puberty. These weights continue to increase as the animals breed so that the mean figures for early pregnancy are 167.8 g followed by 169.6 g for midpregnancy and 201.7 g for late pregnancy. The absolute adrenal weights increase from prepubertal through pubertal stages to the breeding animals with a response similar to and probably associated with the age of the animals. Relative adrenal weigths also increase from early pregnancy through midpregnancy to late pregnancy but do not reach their maximum level until lactation stage (Fig. 3).

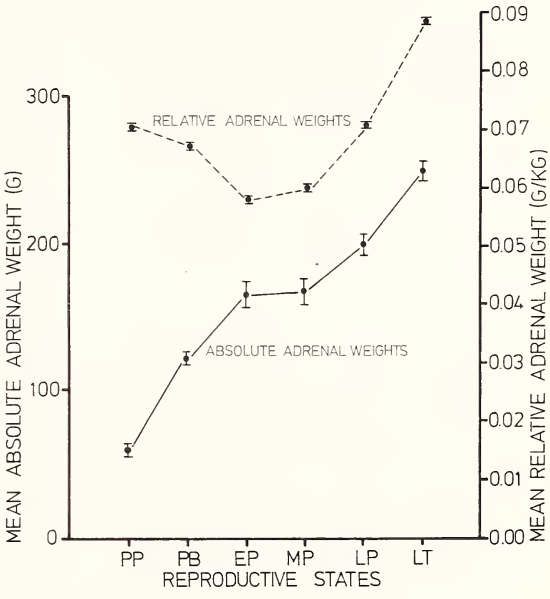

Fig. 3. Adrenal weight changes with the reproductive states of the female elephants. PP = Pre-puberty; PB = Puberty; EP = Early pregnancy; MP = Midpregnancy; LP = Late pregnancy; LT = Lactation

During the breeding period alone, the adrenal weights both absolute and relative, increase from early pregnancy through mid-and late pregnancy to lactation. Comparisons between pregnancy and lactation shows that the mean absolute adrenal weight of 195.7 g (n = 59) for pregnant elephants is lower than 252.4 g (n = 60) for lactating specimens. It is therefore apparent that then mean absolute adrenal weight like the mean relative adrenal weight reaches its peak during lactation.

Seasonal and geographical trends

The data in Table 2 and 3 shows slight differences even within the same age groups but in the final analysis the mean adrenal weight changes are still related to age. Attempts were made to compare the behaviour of elephant adrenal glands obtained from either side of Kazinga channel and the Nile but to no avail. Similarly, any little differences in the adrenal weights, both absolute and relative, that might be noticed between the two park populations are statistically insignificant and geographically inconsistent. In other words, the data was inadequate for seasonal comparison and ultimately there is no suggestion from the available data of any seasonal or geographic trend.

Table 2

Absolute and relative adrenal weights and other measurements of elephants from Murchison Falls National Park

	Wet Season				Dry Season			
	Immature		Mature		Immature		Mature	
	Males	Females	Males	Females	Males	Females	Males	Females
Body weight range	162–2533	117–1562	2182–4089	1427–3480	190–2533	733–1676	2438–3969	1745–4037
Mean body weight	977.7	809.6	3198.3	2759.6	1110.6	1163.9	3172.8	2979.1
			Absolute adrenal weight					
Range	16.6–133.8	15.5–113.0	144–266	97.5–328.2	18–133	53.8–117.0	128–281	102–424
Mean	70.0	54.3	191.5	199.0	68.1	78.7	186.8	212.4
Standard error	14.07	7.70	13.35	10.97	12.07	10.12	11.09	10.88
			Relative adrenal weight					
Range	0.053–0.115	0.051–0.132	0.045–0.071	0.049–0.103	0.046–0.079	0.056–0.081	0.045–0.071	0.040–0.119
Mean	0.0723	0.0757	0.0602	0.0716	0.0636	0.0673	0.0584	0.0707
Standard error	0.00711	0.00628	0.00239	0.00276	0.00286	0.00373	0.00157	0.00295
Sample Size (n)	8	12	11	29	12	6	17	50

Table 3

Absolute and relative adrenal weights and other measurements of elephants from Queen Elizabeth National Park

	Wet Season				Dry Season			
	Immature		Mature		Immature		Mature	
	Males	Females	Males	Females	Males	Females	Males	Females
Body weight range	625–22236	–	3066–3589	1733–4165	105–2246	575–1258	–	1097–3131
Mean body weight	977.7	–	3198.3	2759.6	1543.6	747.2	–	2408.9
			Absolute adrenal weight					
Range	52–149	–	150–223	84.5–596	40–138	34–105	–	77–382
Mean	114.7	–	195.7	233.6	102.5	55.3	–	2065
Standard error	13.41	–	22.98	18.14	10.90	13.22	–	13.11
			Relative adrenal weight					
Range	0.055–0.086	–	0.049–0.070	0.024–0.173	0.053–0.103	0.054–0.104	–	0.058–0.131
Mean	0.075	–	0.0597	0.0866	0.072	0.072	–	0.085
Standard error	0.00499	–	0.00606	0.0055	0.0063	0.0093	–	0.00367
Sample Size (n)	6	0	3	36	10	5	0	30

Discussion

The proportionately heavier right than left adrenal in elephants is in agreement with what other workers found (Jones 1957). As in most mammals, a great variability of adrenal weights exists in elephant populations even when they are of the same sex and age. However, scrutiny of the data shows only small differences between males and females of the same age. These observations, which show little sex differences in adrenal weights of African elephants, tend to differ with many reports on mammalian adrenal behaviour.

Other workers have reported higher female adrenal weights in some mammals (Jones 1957) and in the African elephant (Krumrey and Buss 1969). It is likely that the present report which is an analysis of materials three times the number used by the previous authors, has had a bigger age-spectrum to be able to show the inconsistences in the comparison between the sexes. The present work supports other workers who found little sex differences in the adrenal gland weights of some mammals (Jones 1957).

Like in most other mammals studied, the elephant adrenal glands continue to increase in weight with age from neonatal stage. This concurs with the earlier work of Krumrey and Buss (1969). Relative adrenal weights are high in neonate elephants and drecrease with age up to the time when the animals are sexually mature; and then increase with age thereafter. This may be due to the adrenal gland continuing to increase in weight after the animal has attained its maturity.

There is a definite change in the adrenal weights of elephants as they cross from immaturity to breeding. But I concur with Krumrey and Buss (1969) who found no adrenal weight increase related to sexual maturation. The change is age-influenced and significantly related to breeding rather than attainment of sexual maturity.

The relationship between increased adrenal weights and pregnancy and lactation in female elephants may not only be associated with the stress of breeding but more so with the care of the young. This fact may be underlined by the poaching pressure exerted on the elephants in the game parks, and the long suckling period characteristic of this species. This seems to confirm the observation that the energy demands of mammalian offspring increase throughout pregnancy and lactation (Millar 1975), so that lactation does not only become energetically but also socially the critical period of the breeding cycle.

We are aware that adrenal weights may not always be valid indices of function due to factors which include the presence of immature zones, since there is very little evidence that such zones contribute to cortical function. It is also possible that adrenal weight decreases with excessive stimulation mixed with a misleading increase in adrenal weight due to accumulation of lipids (O'Kelly 1974). However, there were neither decrease in absolute adrenal weight nor consistent seasonal or geographical changes in the adrenal weights of the elephant.

At this stage it is tempting to suggest that 1. adrenal weights might not be a valid index of seasonal function in the elephants or in the tropics; and 2. that we should not expect what occurs in small rodent populations to be duplicated in the largest terrestrial mammal. It is, on the other hand, possible that the African elephant with its close-knit social structure and receiving hostile attention and slaughter over an extended period of time will tend to suffer equally throughout the year in both parks. Then, this all-time harassment would appear to have cut across the seasons.

Acknowledgements and dedication

I would like to thank Prof. Peter T. White who started me on this project and saw me through the initial difficult period of the sampling programme. I am indebted to Dr. Bob Malpas with whom I worked throughout the sampling period. Makerere University Grants Committee is gratefully acknowledged for its financial support.

This article is dedicated to the 'Great Elephants of Lumumba Hall, Makerere University' whose motto, 'The Struggle continues' has not only inspired me but should be adopted by everybody for the conservation of the African elephant.

Zusammenfassung

Nebennierengewichte von Afrikanischen Elefanten (Loxodonta africana)

In den Jahren 1973 und 1974 wurden von 71 männlichen und 172 weiblichen, in West-Uganda geschossenen Elefanten die Nebennieren gesammelt. Die Tiere wurden bei den Murchison-Falls und im Queen Elizabeth-Nationalpark sowohl zur trockenen als auch zur feuchten Jahreszeit erlegt. Die Analyse des Materials brachte eine Reihe von Ergebnissen. Die rechte Nebenniere ist stets schwerer als die linke. Bei gleichaltrigen Individuen findet man nur geringe Geschlechtsunterschiede im Gewicht der Nebennieren. Bei Jungtieren nimmt das Gewicht der Nebennieren pari passu mit dem Alter zu. Weibliche Elefanten zeigen während der Fortpflanzung Änderungen im Gewicht der Nebennieren, die aber statistisch nicht signifikant sind. Es gibt keinen Hinweis auf saisonale oder geographische Variation im Gewicht der Nebennieren von Elefanten gleichen Alters und/oder gleichen Geschlechts. Die dargelegten Ergebnisse werden diskutiert.

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Author's address: Jonathan Baranga, Zoology Department, Makerere University, Kampala, Uganda

Observations on the ecology and behaviour of the Northern White Rhinoceros *(Ceratotherium simum cottoni)*

By R. van Gyseghem

Uganda Institute of Ecology, Queen Elizabeth National Park, Uganda, and Zoologisches Institut der Universität Kaiserslautern

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Abstract

Studied was a population of the Northern White Rhinoceros, *Ceratotherium simum cottoni,* in the Murchison Falls National Park, Uganda, from September 1977 until July 1978. Population status, social organization, territorial behaviour, habitat utilization, activity patterns and feeding ecology were investigated.

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